

CLAIMS

1. A corrosion-inhibiting pigment comprising cobalt, wherein the cobalt is trivalent cobalt, tetravalent cobalt, or combinations thereof, and a valence stabilizer combined to form a cobalt/valence stabilizer complex.

5 2. The pigment of claim 1 wherein the cobalt/valence stabilizer complex has a solubility in water of between about  $1 \times 10^0$  and about  $1 \times 10^{-5}$  moles per liter of cobalt at about  $25^{\circ}\text{C}$  and about 760 Torr.

10 3. The pigment of claim 2 wherein the solubility of the cobalt/valence stabilizer complex in water is between about  $1 \times 10^{-1}$  and about  $1 \times 10^{-4}$  moles per liter of cobalt at about  $25^{\circ}\text{C}$  and about 760 Torr.

4. The pigment of claim 1 wherein there is an electrostatic barrier layer around the cobalt/valence stabilizer complex in aqueous solution.

5. The pigment of claim 1 wherein the cobalt/valence stabilizer complex acts as an ion exchange agent towards corrosive ions.

15 6. The pigment of claim 1 wherein the cobalt/valence stabilizer complex decomposes above about  $100^{\circ}\text{C}$ .

7. The pigment of claim 1 wherein the cobalt/valence stabilizer complex melts above about  $50^{\circ}\text{C}$ .

20 8. The pigment of claim 1 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

9. The pigment of claim 8 wherein the valence stabilizer is the inorganic valence stabilizer selected from molybdates; tungstates; vanadates; niobates; tantalates; tellurates; periodates; iodates; carbonates; antimonates; stannates; titanates; zirconates; hafnates; bismuthates; germanates; arsenates; phosphates; borates; aluminates; and silicates; and combinations thereof.

5 10. The pigment of claim 9 wherein the valence stabilizer is the inorganic valence stabilizer selected from molybdates; tungstates; vanadates; niobates; tantalates; tellurates; periodates; iodates; carbonates; antimonates; and stannates; and combinations thereof.

11. The pigment of claim 9 wherein the cobalt/valence stabilizer complex has a central cavity containing a cobalt ion and an additional ion.

12. The pigment of claim 11 wherein the additional ion is  $B^{+3}$ ,  $Al^{+3}$ ,  $Si^{+4}$ ,  $P^{+5}$ ,  $Ti^{+4}$ ,  $V^{+5}$ ,  $V^{+4}$ ,  $Cr^{+6}$ ,  $Cr^{+3}$ ,  $Mn^{+4}$ ,  $Mn^{+3}$ ,  $Mn^{+2}$ ,  $Fe^{+3}$ ,  $Fe^{+2}$ ,  $Co^{+2}$ ,  $Ni^{+2}$ ,  $Ni^{+3}$ ,  $Ni^{+4}$ ,  $Cu^{+2}$ ,  $Cu^{+3}$ ,  $Zn^{+2}$ ,  $Ga^{+3}$ ,  $Ge^{+4}$ ,  $As^{+5}$ ,  $As^{+3}$ ,  $Zr^{+4}$ , or  $Ce^{+4}$ .

15 13. The pigment of claim 8 wherein the valence stabilizer is the organic valence stabilizer selected from monoamines; diamines; triamines; tetraamines; pentamines; hexamines; five- or six-membered heterocyclic rings containing one to four nitrogen atoms optionally having additional nitrogen, sulfur, or oxygen binding sites; five- or six-membered heterocyclic rings containing one or two sulfur atoms and having additional nitrogen binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional nitrogen binding sites; (two-, three-, four-, six-, eight-, or ten-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; 20 macrocyclic oligothioketones or dithiolenes; diazenes; thio-, amido-, or imido- derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases containing at least two azo, imine, or azine groups; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases with ortho- (for aryl) or alpha- or beta- (for alkyl) substitution; oximes; amidines and imido compounds; dithio ligands; amides;

amino acids; N-(thio)acyl 7-aminobenzylidenimines; (thio)hydroxamates; alpha- or ortho-aminothio(di)carboxylic acids and salts; (thio)semicarbazones; (thio)acyl hydrazones; (thio)carbazones; silylaminoalcohols; thioalkyl amines and imines; hydroxyalkyl imines; (thio)aryl amines and imines; guanylureas; guanidinoureas; 2-nitrosophenols; 2-nitrophenols; N-5 nitrosohydroxylamines; 1,3-monothioketones; monothiomalonamides; 2-thioacetylacetamides; 2-acylthioacetamides; dithiodicarbonic diamides; trithiodicarboxylic acids and salts; monothiocarbamates; monothioethers; dithioethers; trithioethers; tetrathioethers; pentathioethers; hexathioethers; disulfides; monophosphines; diphosphines; triphosphines; tetraphosphines; pentaphosphines; hexaphosphines; five- or six-membered heterocyclic rings containing one or two sulfur atoms optionally having additional sulfur, oxygen, or phosphorus binding sites; five- or six-membered heterocyclic rings containing one to three phosphorus atoms optionally having additional phosphorus, nitrogen, oxygen, or sulfur binding sites; five- or six-membered heterocyclic rings containing one to four nitrogen atoms and having additional phosphorus binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional sulfur or phosphorus binding sites; (five-, seven-, or nine-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; (two- to ten-)membered sulfur, sulfur-oxygen, or sulfur-phosphorus macrocyclics, not including oligothioketones or dithiolenes; (two- to ten-)membered phosphorus, nitrogen-phosphorus, or oxygen-phosphorus macrocyclics; thio-, amido-, or imido- derivatives of phosphonic and diphosphonic acids and salts containing no sulfur binding sites; amido-, or imido-20 derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts containing no sulfur binding sites; dithioperoxydiphosphoramides; dithioperoxydiphosphoric acids and salts; monothioperoxydiphosphoramides; monothioperoxydiphosphoric acids and salts; monothiophosphoric acids; phosphoro(dithioperoxoic) acids and salts; azo compounds, triazenes, formazans, azines, or Schiff Bases; silylamines; silazanes; guanidines and diguanidines; 25 pyridinaldimines; hydrazones; hydramides; nitriles; thioureas and thioamides; ureas and biurets; monothio ligands; diketone ligands; dithioacyl disulfides; tetrathioperoxydicarbonic diamides; (hexa-, penta-, or tetra-)thioperoxydicarbonic acids and salts; 1,2-dithiolates; rhodanines; dithiocarbimates; (thio)xanthates; S-(alkyl- or aryl-thio)thiocarboxylic acids and salts; phosphinodithioformates;

(thio)borates and (thio)boronates; (thio)arsonic acids and salts; (thio)antimonic acids and salts; phosphine and arsine sulfides or oxides; beta-hydroxyketones and -aldehydes; squaric acids and salts; carbonates; carbamates and carbimates; carbazates; imidosulfurous diamides; sulfurdiumines; thiocarbonyl and mercapto oximes; 2-nitrothiophenols; 2-nitrilo(thio)phenols; acylcyanamides; 5 imides; 2-amidinoacetates; beta-ketoamines; 3-aminoacrylamides and 3,3-diaminoacrylamides; 3-aminoacrylic acids and salts and 3-hydroxy-3-aminoacrylic acids and salts; 2-nitroanilines; amine and diazine N-oxides; hydrazides and semicarbazides; (amino- or imino-)aryl phosphines; (thio- or hydroxy-)aryl phosphines; arsines; five- or six-membered heterocyclic rings containing one arsenic atom optionally having additional arsenic binding sites; (two- to six-)membered arsenic macrocyclics; 10 selenoethers; five- or six-membered heterocyclic rings containing one or two selenium atoms optionally having additional selenium binding sites; (two- to six-)membered selenium macrocyclics; 1,3-diselenoketones; 1,1-diselenolates; diselenocarbamates; selenophosphoric acids and salts; selenocarbonates; cyanide, isocyanide, and cyanamide ligands; nitrosyl and nitrite ligands; azide ligands; thiolates and selenolates; (thio)cyanate ligands; diene or bicyclic or tricyclic hydrocarbon ligands; and carbonyl, halogen, and hydroxo ligands; and combinations thereof.

14. The pigment of claim 13 wherein the organic valence stabilizer is selected from monoamines; diamines; triamines; tetraamines; pentamines; hexamines; five- or six-membered heterocyclic rings containing one to four nitrogen atoms optionally having additional nitrogen, sulfur, or oxygen binding sites; five- or six-membered heterocyclic rings containing one or two sulfur atoms and 20 having additional nitrogen binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional nitrogen binding sites; (two-, three-, four-, six-, eight-, or ten-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; macrocyclic oligothioketones or dithiolenes; diazenes; thio-, amido-, or imido- derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; azo compounds, triazenes, formazans, azines, 25 hydrazones, or Schiff Bases containing at least two azo, imine, or azine groups; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases with ortho- (for aryl) or alpha- or beta- (for alkyl) substituted azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases; oximes;

amidines and imido compounds; dithio ligands; amides; amino acids; N-(thio)acyl 7-aminobenzylidenimines; (thio)hydroxamates; alpha- or ortho-aminothio(di)carboxylic acids and salts; (thio)semicarbazones; (thio)acyl hydrazones; (thio)carbazones; silyl aminoalcohols; thioalkyl amines and imines; hydroxyalkyl imines; (thio)aryl amines and imines; guanylureas; guanidinoureas; 2-nitrosophenols; 2-nitrophenols; N-nitrosohydroxylamines; 1,3-monothioketones; monothiomalonamides; 2-thioacylacetamides; 2-acylthioacetamides; dithiodicarbonic diamides; trithiodicarboxylic acids and salts; and monothiocarbamates; and combinations thereof.

15. The pigment of claim 13 wherein the organic valence stabilizer is the diazene selected from diazeneformimidamides; diazeneformamides; diazeneformothioamides; diazenacetimidamides; diazenacetothioamides; diazeneformimidic acids and salts; diazenacetimidic acids and salts; diazenecarbothioic acids and salts; diazenecarbodithioic acids and salts; diazeneformimidothioic acids and salts; diazeneformaldehydes; diazeneformothioaldehydes; diazenacetaldehydes; diazenacetothioaldehydes; diazenediformamides; diazenediformothioamides; diazenediacetamides; diazenediacetothioamides; diazenacetimidothioic acids and salts; imido yldiazenes; diazenediformimidamides; diazenediacetimidamides; diazenediformimidic acids and salts; diazenediacetimidic acids and salts; diazenediformimidothioic acids and salts; diazenediacetimidothioic acids and salts; diazenediacetothioaldehydes; and diimido yldiazenes; and combinations thereof.

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25 16. The pigment of claim 13 wherein the organic valence stabilizer is the thio-, amido-, or imido- derivative of hypophosphoric, phosphoric, or diphosphoric acids and salts selected from phosphoramidimidic triamides; phosphoramidimidic acids and salts; phosphorodiamidimidic acids and salts; phosphorodiamidimidothioic acids and salts; phosphoramidimidothioic acids and salts; phosphorodiamidimidodithioic acids and salts; phosphoramidimidodithioic acids and salts; (di- or mono-)thiohypophosphoric acids and salts; (di- or mono-)thiohypophosphoramides; phosphoramidic

acids and salts; phosphorimidic acids and salts; (di- or mono-)thioimidodiphosphoric acids and salts; (di- or mono-)thiohydrazidodiphosphoric acids and salts; (di- or mono-)thioimidodiphosphoramides; (di- or mono-)thiohydrazidodiphosphoramides; phosphoric triamides; (di- or mono-)thiodiphosphoramides; (di- or mono-)thiodiphosphoric acids and salts; (tetra-, tri-, di-)thiophosphoric acids and salts; phosphoro(dithioperoxo)(mono-, di-, or tri-)thioic acids and salts; phosphorimido(mono-, di-, or tri-)thioic acids and salts; phosphorothioic triamides; phosphoramido(mono, di- or tri-)thioic acids and salts; and phosphorodiamido(mono, di- or tri-)thioic acids and salts; and combinations thereof.

17. The pigment of claim 13 wherein the organic valence stabilizer is a substituent for the ortho-(for aryl) or alpha- or beta- (for alkyl) substituted azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases selected from amino; imino; oximo; diazeno; hydrazido; thiol; mercapto; thiocarbonyl; hydroxy; carbox; and carbonyl substituents, and combinations thereof.

18. The pigment of claim 13 wherein the organic valence stabilizer is the oxime selected from monooximes; dioximes; carbonyl oximes; imine oximes; hydroxy oximes; amino oximes; amido oximes; hydrazone oximes, and azo oximes; and combinations thereof.

19. The pigment of claim 13 wherein the organic valence stabilizer is the amidine and imido compound selected from amidines; diamidines; biguanides; biguanidines; diamidinomethanes; imidoylguanidines; amidinoguanidines; diformamidine oxides, sulfides, and disulfides; imidodicarbonimidic acids and salts; diimidodicarbonimidic acids and salts; thioimidodicarbonimidic acids and salts; thiodiimidodicarbonimidic acids and salts; diimidoylimines; diimidoylhydrazides; imidosulfamides; diimidosulfamides; O-amidinocarbamates; O- or S-amidino(mono-, di-, or peroxy-)thiocarbamates; N-hydroxy(or N,N'-dihydroxy)amidines; and diimidosulfuric acids and salts; and combinations thereof.

20. The pigment of claim 13 wherein the organic valence stabilizer is the dithio ligand selected from dithioimidodialdehydes; dithiohydrazidodialdehydes; dithioimidodicarbonic acids and salts; dithiohydrazidodicarbonic acids and salts; 1,3-dithioketones; 1,2-dithioketones; dithiomalonamides; 2-thioacylthioacetamides; dithioacyl sulfides; trithiodicarbonic diamides; (penta-, tetra-, tri- 5 )thiodicarbonic acids and salts; beta-mercaptopthioketones and -aldehydes; N-(aminomethylthiol)thioureas; dithiooxamides; 1,1-dithiolates; (di- or per-)thiomonocarboxylic acids and salts; (tetra- or per-)thiodicarboxylic acids and salts; (di-, tri-, or per-)thiocarbonates; dithiocarbamates (including N-hydroxydithiocarbamates and N-mercaptodithiocarbamates); and dithiocarbazates; and combinations thereof.

10. The pigment of claim 13 wherein the organic valence stabilizer is the amide selected from monoamides; lactams; amidinoamides; guanidinoamides; imidoylamides; polyamides; and polylactams; and combinations thereof.

22. The pigment of claim 13 wherein the organic valence stabilizer is the thio-, amido-, or imido- derivative of phosphonic and diphosphonic acids and salts selected from phosphonitrile amides; phosphonimidic diamides; phosphonamidimidic acids and salts; phosphonamidimidothioic acids and salts; dithioimidodiphosphonic acids and salts; dithiohydrazidodiphosphonic acids and salts; dithioimidodiphosphonamides; dithiohydrazidodiphosphonamides; dithiodiphosphonamides; dithiodiphosphonic acids and salts; dithioperoxydiphosphonamides; dithioperoxydiphosphonic acids and salts; (di- and tri-)thiophosphonic acids and salts; phosphono(dithioperoxo)thioic acids and salts; 15 phosphono(dithioperoxo)dithioic acids and salts; phosphonimidothioic acids and salts; phosphonimidodithioic acids and salts; phosphonothioic acids and salts; phosphonanidothioic acids and salts; phosphonamidimidodithioic acids and salts; monothioimidodiphosphonic acids and salts; monothiohydrazidodiphosphonic acids and salts; monothioimidodiphosphonamides; monothiohydrazidodiphosphonamides; monothiodiphosphonamides; monothiodiphosphonic acids 20 and salts; monothioperoxydiphosphonamides; monothioperoxydiphosphonic acids and salts; 25

monothiophosphonic acids and salts; and phosphono(dithioperoxoic) acids and salts; and combinations thereof.

23. The pigment of claim 13 wherein the organic valence stabilizer is the amido-, or imido- derivative of hypophosphoric, phosphoric, or diphosphoric acids and salts containing no sulfur binding sites selected from hypophosphoric acids and salts; hypophosphoramides; imidodiphosphoric acids and salts; hydrazidodiphosphoric acids and salts; imidodiphosphoramides; hydrazidodiphosphoramides; and diphosphoramides; and combinations thereof.

10 24. The pigment of claim 13 wherein the organic valence stabilizer is the amido-, or imido- derivative of phosphonic or diphosphonic acids and salts containing no sulfur binding sites selected from imidodiphosphonic acids and salts; hydrazidodiphosphonic acids and salts; imidodiphosphonamides; hydrazidodiphosphonamides; diphosphonamides; phosphonimidic acids and salts; phosphonamidic acids and salts; and phosphonic diamides; and combinations thereof.

15 25. The pigment of claim 13 wherein the organic valence stabilizer is the thiourea and thioamide selected from thioureas; thiocarboxamides; thioacylthioureas, acylthioureas, and thioacylureas; thioaroylthioureas, aroylthioureas, and thioaroylureas; thioimidates; thioguanylureas; guanidinothioureas; amidinothioamides; guanidinothioamides; imidoylthioamides; 3- aminothioacrylamides; thiohydrazides; thiosemicarbazides; (mono- and di-)thiobiurets; (mono- and di-)thioisobiurets; (mono- and di-)thiobiureas; N-(aminomethylol)thioureas; N-(aminomethylthiol)ureas; and beta-mercaptocarboxamides; and combinations thereof.

20 26. The pigment of claim 13 wherein the organic valence stabilizer is the urea and biuret selected from ureas and pseudoureas; biurets, isobiurets, and biureas; acylureas; aroylureas; and N-(aminomethylol)ureas; and combinations thereof.

27. The pigment of claim 13 wherein the organic valence stabilizer is the monothio ligand selected from beta-aminothiones; 3-aminothioacrylic acids and salts; 3-mercaptop-3-aminothioacrylic acids and salts; N-thioacyl benzylidenimines; thioimidodialdehydes; thiohydrazidodialdehydes; thioimidodicarbonic acids and salts; thiohydrazidodicarbonic acids and salts; 1,2-monothioketones; 5 trithioperoxydicarbonic diamides; dithioperoxydicarbonic diamides; dithiodicarbonic acids and salts; trithioperoxydicarbonic acids and salts; beta-hydroxythioketones; beta-hydroxythioaldehydes; beta-mercaptopketones; beta-mercaptopaldehydes; monothiooxamides; beta-mercaptopcarboxylic acids and salts; beta-mercaptopthiocarboxylic acids and salts; beta-hydroxythiocarboxylic acids and salts; S-alkylthiocarboxylic acids and salts; S-arylthiocarboxylic acids and salts; S-alkyldisulfidocarboxylic acids and salts; S-aryldisulfidocarboxylic acids and salts; monothiomonocarboxylic acids and salts; dithiodicarboxylic acids and salts; monothiocarbonates; monothiocarbazates; monothiocarbimates; mercaptoalcohols; and silylmercaptoalcohols; and combinations thereof.

10 28. The pigment of claim 13 wherein the organic valence stabilizer is the diketone ligand selected from imidodialdehydes; hydrazidodialdehydes; imidodicarbonic acids and salts; hydrazidodicarbonic acids and salts; imidodisulfamic acids and salts; imidodisulfuric acids and salts; 1,3-diketones; 1,2-diketones; malonamides; 2-acylacetamides; monothiodicarbonic diamides; monothiodicarbonic acids and salts; dithioperoxydicarbonic acids and salts; trithionic acids and salts; oxamides; and dicarboxylic acids; and combinations thereof.

15 29. The pigment of claim 13 wherein the organic valence stabilizer is the S-(alkyl- or aryl-thio)thiocarboxylic acid and salt selected from S-(alkylthio)thiocarboxylic acids and salts; S-(arylthio)thiocarboxylic acids and salts; S,S-thiobisthiocarboxylic acids and salts; S-(alkyldisulfido)thiocarboxylic acids and salts; S-(aryldisulfido)thiocarboxylic acids and salts; and S,S'-disulfidobisthiocarboxylic acids and salts; and combinations thereof.

20 30. The pigment of claim 13 wherein the organic valence stabilizer is the phosphine and arsine sulfide or oxide selected from phosphine P-sulfides; aminophosphine sulfides; arsine As-sulfides;

aminoarsine sulfides; phosphine P-oxides; aminophosphine oxides; arsine As-oxides; and aminoarsine oxides; and combinations thereof.

31. The pigment of claim 13 wherein a solubility in water of the cobalt/valence stabilizer complex is adjusted by an addition of a substituent group on the organic valence stabilizer.

5 32. The pigment of claim 31 wherein the solubility in water is increased by the addition of the substituent group selected from sulfonate groups (-SO<sub>3</sub><sup>-</sup>); carboxyl groups (-CO<sub>2</sub><sup>-</sup>); hydroxyl groups (-OH); ester groups (-CO<sub>3</sub><sup>-</sup>); carbonyl groups (=C=O); amine groups (-NH<sub>2</sub>); nitrosamine groups (=N-N=O); carbonylnitrene groups (-CO-N); sulfoxide groups (=S=O); sulfone groups (=S[=O]<sub>2</sub>); sulfinyl groups (-N=S=O); sulfodiimines (=S[=NH]<sub>2</sub>); sulfonyl halide groups (-S[=O]<sub>2</sub>X); sulfonamide groups (-S[=O]<sub>2</sub>NH<sub>2</sub>); monohalosulfonamide groups (-S[=O]<sub>2</sub>NHX); dihalosulfonamide groups (-S[=O]<sub>2</sub>MX<sub>2</sub>); halosulfonate groups (-S[=O]<sub>2</sub>OX); halosulfonate amide groups (=N-S[=O]<sub>2</sub>X); aminosulfonate groups (=N-S[=O]<sub>2</sub>OH); iminosulfonate groups (-N[SO<sub>3</sub><sup>-</sup>]<sub>1-2</sub>); phosphonate groups (-PO<sub>3</sub><sup>-2</sup>); phosphonamide groups (-PO<sub>2</sub>NH<sub>2</sub><sup>-</sup>); phosphondiamide groups (-PO[NH<sub>2</sub>]<sub>2</sub>); aminophosphonate groups (=N-PO<sub>3</sub><sup>-2</sup>); and iminophosphonate groups (-N[PO<sub>3</sub><sup>-2</sup>]<sub>1-2</sub>); and combinations thereof.

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33. The pigment of claim 31 wherein the solubility in water is decreased by the addition of the substituent group selected from nitro groups (-NO<sub>2</sub>); perfluoroalkyl groups (-C<sub>x</sub>F<sub>2x+1</sub>); perchloroalkyl groups (-C<sub>x</sub>Cl<sub>2x+1</sub>); nitramine groups (=N-NO<sub>2</sub>); thioketone groups (=C=S); sulfenyl halide groups (-S-X); and sulfur dihaloimide groups (-N=SX<sub>2</sub>); and combinations thereof.

20 34. The pigment of claim 13 wherein an electrostatic barrier layer of the cobalt/valence stabilizer complex is adjusted by an addition of a substituent group on the organic valence stabilizer.

35. The pigment of claim 34 wherein the electrostatic barrier layer is increased by the addition of the substituent group selected from ketones (=C=O); thioketones (=C=S); amides (-C[=O]-NR<sub>2</sub>);

thioamides (-C[=S]-NR<sub>2</sub>); nitriles or cyano groups (-CN); isocyanides (-NC); nitroso groups (-N=O); thionitroso groups (-N=S); nitro groups (-NO<sub>2</sub>); azido groups (-N<sub>3</sub>); cyanamide or cyanonitrene groups (=N-CN); cyanate groups (-O-CN); isocyanate groups (-N=C=O); thiocyanate groups (-S-CN); isothiocyanate groups (-N=C=S); nitrosamine groups (=N-N=O); thionitrosamine groups (=N-N=S); nitramine groups (=N-NO<sub>2</sub>); thionitramine groups (=N-NS<sub>2</sub>); carbonylnitrene groups (-CO-N); thiocarbonylnitrene groups (-CS-N); sulfenyl halides (-S-X); sulfoxides (=S=O); sulfones (=S[=O]<sub>2</sub>); sulfinyl groups (-N=S=O); thiosulfinyl groups (-N=S=S); sulfenyl thiocyanato groups (-S-S-CN); sulfenyl cyanato groups (-S-O-CN); sulfodiimine groups (=S[=NH]<sub>2</sub>); sulfur dihaloimido groups (-N=SX<sub>2</sub>); sulfur oxide dihaloimido groups (-N=S[=O]X<sub>2</sub>); aminosulfur oxide trihalide groups (=N-S[=O]X<sub>3</sub>); sulfonyl azide groups (-S[=O]<sub>2</sub>N<sub>3</sub>); sulfonyl thiocyanate groups (-S[=O]<sub>2</sub>SCN); sulfonyl cyanate groups (-S[=O]<sub>2</sub>OCN); sulfonyl cyanide groups (-S[=O]<sub>2</sub>CN); halosulfonate groups (-S[=O]<sub>2</sub>O<sup>+</sup>X<sup>-</sup>); phosphonyl thiocyanate groups (-P[=O]OHSCN); phosphonyl cyanate groups (-P[=O]OHOCN); and phosphonyl cyanide groups (-P[=O]OHCN); and combinations thereof.

36. The pigment of claim 1 further comprising a solubility control agent.

15 37. The pigment of claim 36 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

38. The pigment of claim 37 wherein the solubility control agent is the cationic solubility control agent selected from H<sup>+</sup>; Li<sup>+</sup>; Na<sup>+</sup>; K<sup>+</sup>; Rb<sup>+</sup>; Cs<sup>+</sup>; NH<sub>4</sub><sup>+</sup>; Mg<sup>+2</sup>; Ca<sup>+2</sup>; Sr<sup>+2</sup>; Be<sup>+2</sup>; Ba<sup>+2</sup>; Y<sup>+3</sup>; La<sup>+3</sup>; Ce<sup>+3</sup>; Ce<sup>+4</sup>; Nd<sup>+3</sup>; Pr<sup>+3</sup>; Sc<sup>+3</sup>; Sm<sup>+3</sup>; Eu<sup>+3</sup>; Eu<sup>+2</sup>; Gd<sup>+3</sup>; Tb<sup>+3</sup>; Dy<sup>+3</sup>; Ho<sup>+3</sup>; Er<sup>+3</sup>; Tm<sup>+3</sup>; Yb<sup>+3</sup>; Lu<sup>+3</sup>; Ti<sup>+4</sup>; Zr<sup>+4</sup>; Ti<sup>+3</sup>; Hf<sup>+4</sup>; Nb<sup>+5</sup>; Ta<sup>+5</sup>; Nb<sup>+4</sup>; Ta<sup>+4</sup>; V<sup>+5</sup>; V<sup>+4</sup>; V<sup>+3</sup>; Mo<sup>+6</sup>; W<sup>+6</sup>; Mo<sup>+5</sup>; W<sup>+5</sup>; Mo<sup>+4</sup>; W<sup>+4</sup>; Cr<sup>+3</sup>; Mn<sup>+2</sup>; Mn<sup>+3</sup>; Mn<sup>+4</sup>; Fe<sup>+2</sup>; Fe<sup>+3</sup>; Co<sup>+2</sup>; Co<sup>+3</sup>; Ni<sup>+2</sup>; Ni<sup>+3</sup>; Ni<sup>+4</sup>; Ru<sup>+2</sup>; Ru<sup>+3</sup>; Ru<sup>+4</sup>; Rh<sup>+3</sup>; Ir<sup>+3</sup>; Rh<sup>+2</sup>; Ir<sup>+2</sup>; Pd<sup>+4</sup>; Pt<sup>+4</sup>; Pd<sup>+2</sup>; Pt<sup>+2</sup>; Os<sup>+4</sup>; Cu<sup>+</sup>; Cu<sup>+2</sup>; Cu<sup>+3</sup>; Ag<sup>+</sup>; Ag<sup>+2</sup>; Ag<sup>+3</sup>; Au<sup>+</sup>; Au<sup>+2</sup>; Au<sup>+3</sup>; Zn<sup>+2</sup>; Cd<sup>+2</sup>; Hg<sup>+</sup>; Hg<sup>+2</sup>; Al<sup>+3</sup>; Ga<sup>+3</sup>; Ga<sup>+</sup>; In<sup>+3</sup>; In<sup>+</sup>; Tl<sup>+3</sup>; Tl<sup>+</sup>; Ge<sup>+4</sup>; Ge<sup>+2</sup>; Sn<sup>+4</sup>; Sn<sup>+2</sup>; Pb<sup>+4</sup>; Pb<sup>+2</sup>; Sb<sup>+3</sup>; Sb<sup>+5</sup>; As<sup>+3</sup>; As<sup>+5</sup>; Bi<sup>+3</sup>; Bi<sup>+5</sup>; organic compounds containing at least one N<sup>+</sup> site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least

one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; and quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; and combinations thereof.

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39. The pigment of claim 38 wherein the cationic solubility control agent is selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; and quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; and combinations thereof.

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40. The pigment of claim 37 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates;

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heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferrates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferrates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferates; 5 nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; stibonates; cyanides; cyanochromates; cyanonickelates; cyanatochromates; cyanatonickelates; thiocyanatochromates; thiocyanatonickelates; cyanamidochromates; cyanamidonickelates; nitritonickelates; arsonates; diarsonates; triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites; fluoroarsenates; chloroarsenates; selenates; selenites; fluorothallates; chlorothallates; iodomercury anions; chloromercurates; bromomercurates; osmates; fluoronickelates; chromates; Reinecke's salt; and vanadates; and combinations thereof.

20 41. The pigment of claim 40 wherein the anionic solubility control agent is selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates;

dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; and stibonates; and combinations thereof.

42. The pigment of claim 1 wherein the cobalt/valence stabilizer complex is adsorbed or mixed onto, into, or with an inert medium selected from oxides; hydroxides; phosphates; borates; silicates; carbonates; aluminates; titanates; molybdates; tungstates; oxalates; and polymers; and combinations thereof.

20 43. The pigment of claim 1 wherein the pigment is colored.

44. The pigment of claim 1 wherein the pigment exhibits a color change between cobalt oxidation states.

45. The pigment of claim 1 wherein the pigment is light-fast.

46. A method of making a corrosion-inhibiting pigment comprising:  
providing a solvent;  
providing a cobalt source in the solvent forming a cobalt solution;  
providing a valence stabilizer; and  
5 combining the cobalt source and the valence stabilizer to form a cobalt/valence stabilizer complex.

47. The method of claim 46 wherein the cobalt source is selected from divalent cobalt sources; trivalent cobalt sources; and tetravalent cobalt sources; and combinations thereof.

48. The method of claim 46 further comprising oxidizing the cobalt source.

49. The method of claim 48 wherein the cobalt source is oxidized by adding an oxidizer to the cobalt solution.

50. The method of claim 49 wherein the oxidizer is a dissolved solid, a liquid, or a gas.

51. The method of claim 49 wherein the oxidizer is selected from peroxides; superoxides; persulfates; perborates; pernitrates; perphosphates; percarbonates; persilicates; peraluminates; 15 pertitanates; perzirconates; permolybdates; pertungstates; pervanadates; organic peroxyacid derivatives; ozone; hypochlorites; chlorates; perchlorates; nitrates; nitrites; vanadates; iodates; hypobromites; chlorites; bromates; permanganates; periodates; dissolved oxygen; dissolved chlorine; and dissolved fluorine; and combinations thereof.

52. The method of claim 48 wherein the cobalt source is oxidized by electrolysis.

20 53. The method of claim 46 wherein the cobalt/valence stabilizer complex is formed by a process selected from precipitation, evaporation, salting out with chemicals, freezing, freeze drying, and

firing at an elevated temperature.

54. The method of claim 53 wherein the cobalt/valence stabilizer complex is formed by precipitation.

55. The method of claim 46 wherein the cobalt source is selected from cobalt nitrate, cobalt sulfate, cobalt perchlorate, cobalt chloride, cobalt fluoride, cobalt bromide, cobalt iodide, cobalt bromate, cobalt chlorate, cobalt fluosilicate, cobalt fluotitanate, cobalt fluozirconate, cobalt fluoborate, cobalt fluoaluminate, cobalt formate, cobalt acetate, cobalt propionate, cobalt butyrate, cobalt benzoate, cobalt glycolate, cobalt lactate, cobalt tartronate, cobalt malate, cobalt tartrate, cobalt citrate, cobalt benzenesulfonate, cobalt thiocyanate, cobalt acetylacetone, ammonium cobalt sulfate, ammonium cobalt nitrate, ammonium cobalt chloride, ammonium cobalt bromide, hexaamminecobalt chloride, hexaamminecobalt bromide, hexaamminecobalt nitrate, pentaamminecobalt chloride, pentaamminecobalt bromide, pentaamminecobalt nitrate, lithium cobaltinitrite, sodium cobaltinitrite, tris(ethylenediamine)cobalt chloride, tris(ethylenediamine)cobalt nitrate, bipyridine complexes of trivalent cobalt, phenanthroline complexes of trivalent cobalt, and cobaltcarbonates, and combinations thereof.

56. The method of claim 46 wherein the solvent comprises water.

57. The method of claim 46 wherein the solvent comprises an organic solvent.

58. The method of claim 57 wherein the organic solvent is methanol, ethanol, n-propanol, isopropanol, n-butanol, isobutanol, sec-butanol, benzyl alcohol, glycerol, ethylene glycol, propylene glycol, cresol, cyclohexanol, butyl Carbitol, Cellosolve, methyl Cellosolve, ethyl lactate, acetone, methyl ethyl ketone, diethyl ketone, methyl isobutyl ketone, cyclohexanone, acetophenone, diethyl ether, isopropyl ether, furan, tetrahydrofuran, dioxane, tetrahydropyran, methyl formate, ethyl formate, methyl acetate, ethyl acetate, methyl propionate, ethyl propionate, methyl butyrate, ethyl

butyrate, propylene oxide, acetic acid, propionic acid, butyrolactone, ethylene carbonate, propylene carbonate, benzaldehyde, propyl amine, diethyl amine, ethanolamine, aniline, pyridine, acetonitrile, dimethylformamide, propionitrile, nitrobenzene, hexane, heptane, octane, nonane, decane, undecane, dodecane, cyclohexane, benzene, toluene, xylene, mineral spirits, kerosene, gasoline, carbon 5 tetrachloride, chloroform, methylene chloride, dichloroethane, trichloroethane, trichloroethylene, chlorobenzene, Freon 113, Stoddard's solvent, carbon disulfide, dimethyl sulfoxide, or hexamethylphosphoric triamide, or combinations thereof.

59. The method of claim 46 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

10 60. The method of claim 46 further comprising providing a solubility control agent.

61. The method of claim 60 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

62. The method of claim 61 wherein the solubility control agent is the cationic solubility control agent selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Be^{+2}$ ;  $Ba^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $V^{+5}$ ;  $V^{+4}$ ;  $V^{+3}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Cr^{+3}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ni^{+2}$ ;  $Ni^{+3}$ ;  $Ni^{+4}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Os^{+4}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Cd^{+2}$ ;  $Hg^+$ ;  $Hg^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Tl^{+3}$ ;  $Tl^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Pb^{+4}$ ;  $Pb^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $As^{+3}$ ;  $As^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic 15 compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; and quaternary ammonium compounds 20

having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; and combinations thereof.

63. The method of claim 62 wherein the cationic solubility control agent is selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one iodonium site; and quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; and combinations thereof.

64. The method of claim 61 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides;

cyanamidoferates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferrates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; 5 (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; stibonates; cyanides; cyanochromates; cyanonickelates; cyanatochromates; cyanatonickelates; thiocyanatochromates; thiocyanatonickelates; cyanamidochromates; cyanamidonickelates; nitrtonickelates; arsonates; diarsonates; triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites; fluoroarsenates; chloroarsenates; selenates; selenites; fluorothallates; chlorothallates; iodomercury anions; chloromercurates; bromomercurates; osmates; fluoronickelates; chromates; Reinecke's salt; and vanadates; and combinations thereof.

65. The method of claim 64 wherein the anionic solubility control agent is selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; 20 fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; 25 dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferates; cyanatocobaltates;

cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitroferates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; and stibonates; and combinations thereof.

66. The method of claim 46 wherein the valence stabilizer is provided by adding it to the cobalt solution.

67. The method of claim 46 wherein the valence stabilizer is provided as a separate solution.

68. The method of claim 60 wherein the solubility control agent is provided by adding the solubility control agent to the cobalt solution.

69. The method of claim 60 whereby the solubility control agent is provided by adding the solubility control agent to a separate solution containing the valence stabilizer.

70. The method of claim 60 wherein the solubility control agent is provided as a separate solution.

71. The method of claim 46 further comprising heating the cobalt solution.

72. The method of claim 46 further comprising cooling the cobalt solution.

73. The method of claim 46 further comprising adjusting the pH of the cobalt solution using a compound selected from acids and bases.

74. The method of claim 46 further comprising adsorbing or mixing the cobalt/valence stabilizer complex onto, into, or with an inert medium selected from oxides; hydroxides; phosphates; borates; silicates; carbonates; aluminates; titanates; molybdates; tungstates; oxalates; and polymers; and combinations thereof.

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75. A method for treating a surface for corrosion resistance, comprising:  
providing a substrate to be coated; and

applying a corrosion-inhibiting pigment comprising cobalt, where the cobalt is trivalent cobalt, tetravalent cobalt, or combinations thereof, and a valence stabilizer combined to form a cobalt/valence stabilizer complex.

76. The method of claim 75 wherein the substrate is subject to water-based electrochemical corrosion.

77. The method of claim 75 wherein the cobalt/valence stabilizer complex has a solubility in water of between about  $1 \times 10^0$  and about  $1 \times 10^{-5}$  moles per liter of cobalt at about 25°C and about 760 Torr.

78. The method of claim 77 wherein the solubility of the cobalt/valence stabilizer complex in water is between about  $1 \times 10^{-1}$  and about  $1 \times 10^{-4}$  moles per liter of cobalt at about 25°C and about 760 Torr.

79. The method of claim 75 wherein there is an electrostatic barrier layer around the cobalt/valence stabilizer complex in aqueous solution.

80. The method of claim 75 wherein the cobalt/valence stabilizer complex acts as an ion exchange agent towards corrosive ions.

5 81. The method of claim 75 wherein the cobalt/valence stabilizer complex decomposes at a temperature above about 100°C.

82. The method of claim 75 wherein the cobalt/valence stabilizer complex melts at a temperature above about 50°C.

10 83. The method of claim 75 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

84. The method of claim 77 wherein the cobalt/valence stabilizer complex further comprises a solubility control agent.

85. The method of claim 84 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

15 86. The method of claim 85 wherein the solubility control agent is the cationic solubility control agent selected from H<sup>+</sup>; Li<sup>+</sup>; Na<sup>+</sup>; K<sup>+</sup>; Rb<sup>+</sup>; Cs<sup>+</sup>; NH<sub>4</sub><sup>+</sup>; Mg<sup>+2</sup>; Ca<sup>+2</sup>; Sr<sup>+2</sup>; Be<sup>+2</sup>; Ba<sup>+2</sup>; Y<sup>+3</sup>; La<sup>+3</sup>; Ce<sup>+3</sup>; Ce<sup>+4</sup>; Nd<sup>+3</sup>; Pr<sup>+3</sup>; Sc<sup>+3</sup>; Sm<sup>+3</sup>; Eu<sup>+3</sup>; Eu<sup>+2</sup>; Gd<sup>+3</sup>; Tb<sup>+3</sup>; Dy<sup>+3</sup>; Ho<sup>+3</sup>; Er<sup>+3</sup>; Tm<sup>+3</sup>; Yb<sup>+3</sup>; Lu<sup>+3</sup>; Ti<sup>+4</sup>; Zr<sup>+4</sup>; Ti<sup>+3</sup>; Hf<sup>+4</sup>; Nb<sup>+5</sup>; Ta<sup>+5</sup>; Nb<sup>+4</sup>; Ta<sup>+4</sup>; V<sup>+5</sup>; V<sup>+4</sup>; V<sup>+3</sup>; Mo<sup>+6</sup>; W<sup>+6</sup>; Mo<sup>+5</sup>; W<sup>+5</sup>; Mo<sup>+4</sup>; W<sup>+4</sup>; Cr<sup>+3</sup>; Mn<sup>+2</sup>; Mn<sup>+3</sup>; Mn<sup>+4</sup>; Fe<sup>+2</sup>; Fe<sup>+3</sup>; Co<sup>+2</sup>; Co<sup>+3</sup>; Ni<sup>+2</sup>; Ni<sup>+3</sup>; Ni<sup>+4</sup>; Ru<sup>+2</sup>; Ru<sup>+3</sup>; Ru<sup>+4</sup>; Rh<sup>+3</sup>; Ir<sup>+3</sup>; Rh<sup>+2</sup>; Ir<sup>+2</sup>; Pd<sup>+4</sup>; Pt<sup>+4</sup>; Pd<sup>+2</sup>; Pt<sup>+2</sup>; Os<sup>+4</sup>; Cu<sup>+</sup>; Cu<sup>+2</sup>; Cu<sup>+3</sup>; Ag<sup>+</sup>; Ag<sup>+2</sup>; Ag<sup>+3</sup>; Au<sup>+</sup>; Au<sup>+2</sup>; Au<sup>+3</sup>; Zn<sup>+2</sup>; Cd<sup>+2</sup>; Hg<sup>+</sup>; Hg<sup>+2</sup>; Al<sup>+3</sup>; Ga<sup>+3</sup>; Ga<sup>+</sup>; In<sup>+3</sup>; In<sup>+</sup>; Tl<sup>+3</sup>; Tl<sup>+</sup>; Ge<sup>+4</sup>; Ge<sup>+2</sup>; Sn<sup>+4</sup>; Sn<sup>+2</sup>; Pb<sup>+4</sup>; Pb<sup>+2</sup>; Sb<sup>+3</sup>; Sb<sup>+5</sup>; As<sup>+3</sup>; As<sup>+5</sup>; Bi<sup>+3</sup>; Bi<sup>+5</sup>; organic

compounds containing at least one  $\text{N}^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; and quaternary ammonium compounds having a formula  $\text{NR}_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; and combinations thereof.

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87. The method of claim 86 wherein the cationic solubility control agent is selected from H<sup>+</sup>; Li<sup>+</sup>; Na<sup>+</sup>; K<sup>+</sup>; Rb<sup>+</sup>; Cs<sup>+</sup>; NH<sub>4</sub><sup>+</sup>; Mg<sup>+2</sup>; Ca<sup>+2</sup>; Sr<sup>+2</sup>; Y<sup>+3</sup>; La<sup>+3</sup>; Ce<sup>+3</sup>; Ce<sup>+4</sup>; Nd<sup>+3</sup>; Pr<sup>+3</sup>; Sc<sup>+3</sup>; Sm<sup>+3</sup>; Eu<sup>+3</sup>; Eu<sup>+2</sup>; Gd<sup>+3</sup>; Tb<sup>+3</sup>; Dy<sup>+3</sup>; Ho<sup>+3</sup>; Er<sup>+3</sup>; Tm<sup>+3</sup>; Yb<sup>+3</sup>; Lu<sup>+3</sup>; Ti<sup>+4</sup>; Zr<sup>+4</sup>; Ti<sup>+3</sup>; Hf<sup>+4</sup>; Nb<sup>+5</sup>; Ta<sup>+5</sup>; Nb<sup>+4</sup>; Ta<sup>+4</sup>; Mo<sup>+6</sup>; W<sup>+6</sup>; Mo<sup>+5</sup>; W<sup>+5</sup>; Mo<sup>+4</sup>; W<sup>+4</sup>; Mn<sup>+2</sup>; Mn<sup>+3</sup>; Mn<sup>+4</sup>; Fe<sup>+2</sup>; Fe<sup>+3</sup>; Co<sup>+2</sup>; Co<sup>+3</sup>; Ru<sup>+2</sup>; Ru<sup>+3</sup>; Ru<sup>+4</sup>; Rh<sup>+3</sup>; Ir<sup>+3</sup>; Rh<sup>+2</sup>; Ir<sup>+2</sup>; Pd<sup>+4</sup>; Pt<sup>+4</sup>; Pd<sup>+2</sup>; Pt<sup>+2</sup>; Cu<sup>+</sup>; Cu<sup>+2</sup>; Cu<sup>+3</sup>; Ag<sup>+</sup>; Ag<sup>+2</sup>; Ag<sup>+3</sup>; Au<sup>+</sup>; Au<sup>+2</sup>; Au<sup>+3</sup>; Zn<sup>+2</sup>; Al<sup>+3</sup>; Ga<sup>+3</sup>; Ga<sup>+</sup>; In<sup>+3</sup>; In<sup>+</sup>; Ge<sup>+4</sup>; Ge<sup>+2</sup>; Sn<sup>+4</sup>; Sn<sup>+2</sup>; Sb<sup>+3</sup>; Sb<sup>+5</sup>; Bi<sup>+3</sup>; Bi<sup>+5</sup>; organic compounds containing at least one N<sup>+</sup> site; organic compounds containing at least one phosphonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one iodonium site; and quaternary ammonium compounds having a formula NR<sub>4</sub><sup>+</sup>, where R is an alkyl, aromatic, or acyclic organic constituent; and combinations thereof.

20 88. The method of claim 85 wherein the solubility control agent is the anionic solubility control agent is selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites; phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates;

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sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; stibonates; cyanides; cyanochromates; cyanonickelates; cyanatochromates; cyanatonickelates; thiocyanatochromates; thiocyanatonickelates; cyanamidochromates; cyanamidonickelates; nitritonickelates; arsonates; diarsonates; triarsonates; organic selenates; diselenates; triselenates; arsenates; arsenites; fluoroarsenates; chloroarsenates; selenates; selenites; fluorothallates; chlorothallates; iodomercury anions; chloromercurates; bromomercurates; osmates; fluoronickelates; chromates; Reinecke's salt; and vanadates; and combinations thereof.

89. The method of claim 85 wherein the anionic solubility control agent is selected from fluorotitanates; chlorotitanates; fluorozirconates; chlorozirconates; fluoroniobates; chloroniobates; fluorotantalates; chlorotantalates; molybdates; tungstates; permanganates; fluoromanganates; chloromanganates; fluoroferrates; chloroferrates; fluorocobaltates; chlorocobaltates; fluorozincates; chlorozincates; borates; fluoroborates; fluoroaluminates; chloroaluminates; carbonates; silicates; fluorosilicates; fluorostannates; nitrates; nitrites; azides; cyanamides; phosphates; phosphites;

5 phosphonates; phosphinites; thiophosphates; thiophosphites; thiophosphonates; thiophosphinites; fluorophosphates; fluoroantimonates; chloroantimonates; sulfates; sulfites; sulfonates; thiosulfates; dithionites; dithionates; fluorosulfates; tellurates; fluorides; chlorides; chlorates; perchlorates; bromides; bromates; iodides; iodates; periodates; heteropolyanions; ferricyanides; ferrocyanides; cyanocobaltates; cyanocuprates; cyanomanganates; cyanates; cyanatoferates; cyanatocobaltates; cyanatocuprates; cyanatomanganates; thiocyanates; thiocyanatoferates; thiocyanatocobaltates; thiocyanatocuprates; thiocyanatomanganates; cyanamides; cyanamidoferates; cyanamidocobaltates; cyanamidocuprates; cyanamidomanganates; nitritoferates; nitritocobaltates; azides; (thio)carboxylates; di(thio)carboxylates; tri(thio)carboxylates; tetra(thio)carboxylates; (thio)phenolates; di(thio)phenolates; tri(thio)phenolates; tetra(thio)phenolates; (thio)phosphonates; di(thio)phosphonates; tri(thio)phosphonates; (thio)phosphonamides; di(thio)phosphonamides; tri(thio)phosphonamides; amino(thio)phosphonates; diamino(thio)phosphonates; triamino(thio)phosphonates; imino(thio)phosphonates; diimino(thio)phosphonates; (thio)sulfonates; di(thio)sulfonates; tri(thio)sulfonates; (thio)sulfonamides; di(thio)sulfonamides; tri(thio)sulfonamides; amino(thio)sulfonates; diamino(thio)sulfonates; triamino(thio)sulfonates; imino(thio)sulfonates; diimino(thio)sulfonates; (thio)borates; di(thio)borates; (thio)boronates; organic silicates; and stibonates; and combinations thereof.

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90. The method of claim 82 wherein the cobalt/valence stabilizer complex is adsorbed onto, into, or mixed with an inert medium selected from oxides; hydroxides; phosphates; borates; silicates; 20 carbonates; aluminates; titanates; molybdates; tungstates; oxalates; and polymers; and combinations thereof.

91. The method of claim 75 wherein the pigment is colored.

92. The method of claim 75 wherein the pigment exhibits a color change between cobalt oxidation states.

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93. The method of claim 75 wherein the pigment is light-fast.
94. The method of claim 75 wherein the substrate is selected from metals; semimetals; semiconductors; composite materials with anisotropic electrical conductivity; and materials in a conductive or dielectric medium.
95. The method of claim 75 further comprising surface treating the substrate before applying the pigment.
96. The method of claim 75 further comprising applying a coating to the substrate before applying the pigment.
97. The method of claim 75 further comprising applying a coating concurrently with applying the pigment.
98. The method of claim 75 further comprising applying a coating to the substrate, the coating selected from organic coatings, and inorganic coatings, and combinations thereof.
99. The method of claim 98 wherein the coating is the organic coating selected from alkyd-type primers; acrylic primers; polyester primers; epoxy primers; conductive primers; organic sol-gels; ketimine coatings; polyvinyl coatings; acrylic thermoplastics; asphaltic and coal tar thermoplastics; polyamide thermoplastics; polyethylene dispersion thermoplastics; fluorocarbon thermoplastics; chlorocarbon thermoplastics; silicone thermosets; polyurethane thermosets; polyester thermosets; epoxy-amine thermosets; epoxy-amide thermosets; epoxy-ester thermosets; epoxy-coal tar thermosets; furane thermosets; phenolic thermosets; butadiene styrene elastomers; chlorinated rubber elastomers; polysulfonated elastomers; and neoprene elastomers; and combinations thereof.

100. The method of claim 98 wherein the coating is the inorganic coating selected from low temperature enamels; low temperature glass frits; carbonaceous coatings; zeolites; and inorganic sol-gels; and combinations thereof.

101. A corrosion-inhibiting pigment comprising cobalt, wherein the cobalt is trivalent cobalt, tetravalent cobalt, or combinations thereof, and a valence stabilizer combined to form a cobalt/valence stabilizer complex, wherein the cobalt/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.

102. A method of making a corrosion-inhibiting pigment comprising:  
providing a solvent;  
providing a cobalt source in the solvent forming a cobalt solution;  
providing a valence stabilizer; and  
combining the cobalt source and the valence stabilizer to form a cobalt/valence stabilizer complex, wherein the cobalt/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.

15 103. A method for treating a surface for corrosion resistance, comprising:  
providing a substrate to be coated; and  
applying a cobalt-inhibiting pigment comprising cobalt, wherein the cobalt is trivalent cobalt, tetravalent cobalt, or combinations thereof, and a valence stabilizer combined to form a cobalt/valence stabilizer complex, wherein the cobalt/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.